US009280236B2

(12) **United States Patent**
Hwang et al.

(10) **Patent No.: US 9,280,236 B2**
(45) **Date of Patent: Mar. 8, 2016**

(54) **DISPLAY DRIVING CIRCUIT WITH PHOTO DETECTING INPUT**

(71) Applicant: **Integrated Digital Technologies, Inc.**, Hsinchu (TW)

(72) Inventors: **Naejye Hwang**, Hsinchu (TW); **Shen-Tai Liaw**, Hsinchu (TW); **Yang-Hui Chang**, Hsinchu County (TW)

(73) Assignee: **Integrated Digital Technologies, Inc.**, Hsinchu Science Park, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/084,629**

(22) Filed: **Nov. 20, 2013**

(65) **Prior Publication Data**

US 2014/0139490 A1 May 22, 2014

Related U.S. Application Data

(60) Provisional application No. 61/728,242, filed on Nov. 20, 2012.

(51) **Int. Cl.**

G06F 3/042	(2006.01)
G02F 1/133	(2006.01)
G09G 5/00	(2006.01)

(52) **U.S. Cl.**

CPC ***G06F 3/042*** (2013.01); ***G02F 1/133*** (2013.01); ***G06F 3/0421*** (2013.01); ***G09G 5/00*** (2013.01); *G02F 2001/13312* (2013.01)

(58) **Field of Classification Search**

CPC G06F 3/042–3/0428; G02F 1/133; G02F 2001/13312; G09G 5/00

USPC 345/173–178; 178/18.09

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,323,718	B2 *	1/2008	Chen et al.	257/72
7,742,041	B2 *	6/2010	Lee et al.	345/173
7,889,183	B2 *	2/2011	Lee et al.	345/173
8,325,155	B2 *	12/2012	Chang et al.	345/175
8,345,173	B2 *	1/2013	Cho	349/12
8,368,656	B2 *	2/2013	Wang et al.	345/173
8,368,677	B2 *	2/2013	Yamamoto	345/207
8,497,835	B2 *	7/2013	Kim	345/107
8,575,536	B2	11/2013	Chang	

(Continued)

FOREIGN PATENT DOCUMENTS

CN	101082744	A	12/2007
CN	101251783	A	8/2008

(Continued)

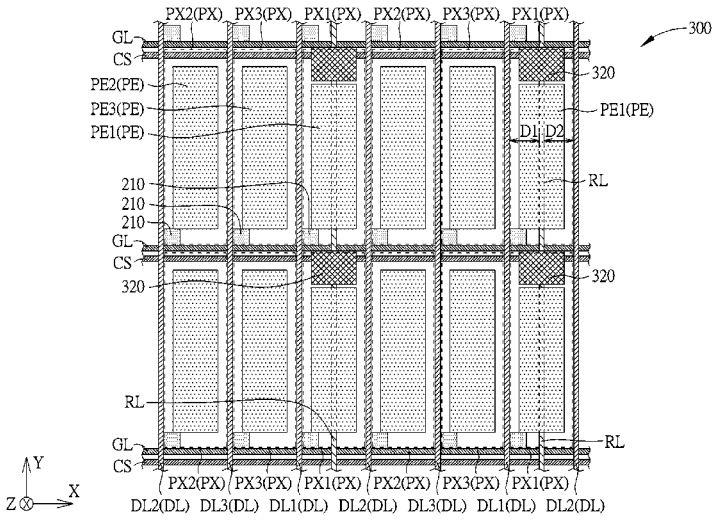
Primary Examiner — Dmitriy Bolotin

(74) *Attorney, Agent, or Firm* — Winston Hsu; Scott Margo

(57) **ABSTRACT**

A display driving circuit with photo detecting input includes pixel regions, pixel electrodes, gate lines, data lines, at least one photo detecting unit and at least one readout line. The gate lines cross the data lines. The data lines include a first data line and a second data line disposed adjacently to each other. There is no data line disposed between the first data line and the second data line. The photo detecting unit is electrically connected to one of the gate lines. The readout line is electrically connected to the photo detecting unit and disposed between the first data line and the second data line. A first spacing between first data line and the readout line is wider than or equal to a second spacing between the second data line and the readout line, and the first spacing is smaller than or equal to triple the second spacing.

13 Claims, 9 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2003/0076295	A1*	4/2003	Nakajima	345/156
2003/0156087	A1*	8/2003	Boer et al.	345/92
2003/0179323	A1*	9/2003	Abileah et al.	349/24
2004/0113877	A1*	6/2004	Abileah et al.	345/92
2005/0275616	A1*	12/2005	Park et al.	345/102
2006/0077186	A1*	4/2006	Park et al.	345/173
2006/0119590	A1*	6/2006	Park et al.	345/175
2007/0109239	A1*	5/2007	den Boer et al.	345/87
2007/0187720	A1*	8/2007	Park et al.	257/206
2007/0257259	A1*	11/2007	Chen et al.	257/59
2008/0062156	A1*	3/2008	Abileah et al.	345/204
2008/0121442	A1*	5/2008	Boer et al.	178/18.09
2008/0174706	A1*	7/2008	Kwon et al.	349/12
2010/0315377	A1*	12/2010	Chang et al.	345/175
2011/0169772	A1*	7/2011	Liu et al.	345/175
2011/0175846	A1*	7/2011	Wang et al.	345/174
2011/0216023	A1*	9/2011	Kurokawa et al.	345/173
2011/0310036	A1*	12/2011	Juan et al.	345/173
2012/0056835	A1*	3/2012	Choo et al.	345/173
2012/0092302	A1*	4/2012	Imai et al.	345/175
2012/0139866	A1*	6/2012	Jung et al.	345/174
2012/0241768	A1*	9/2012	Murai et al.	257/84
2012/0268356	A1*	10/2012	Kim et al.	345/84
2014/0015801	A1*	1/2014	Chung et al.	345/175

FOREIGN PATENT DOCUMENTS

CN	101542360	A	9/2009
CN	101598864	A	12/2009
CN	102566815	A	7/2012
JP	2008304900	A	12/2008
JP	2010245078	A	10/2010
KR	1020090095890	A	9/2009
KR	1020100069901	A	6/2010
KR	1020110100954	A	9/2011
TW	200743886		12/2007
TW	201100917		1/2011

* cited by examiner

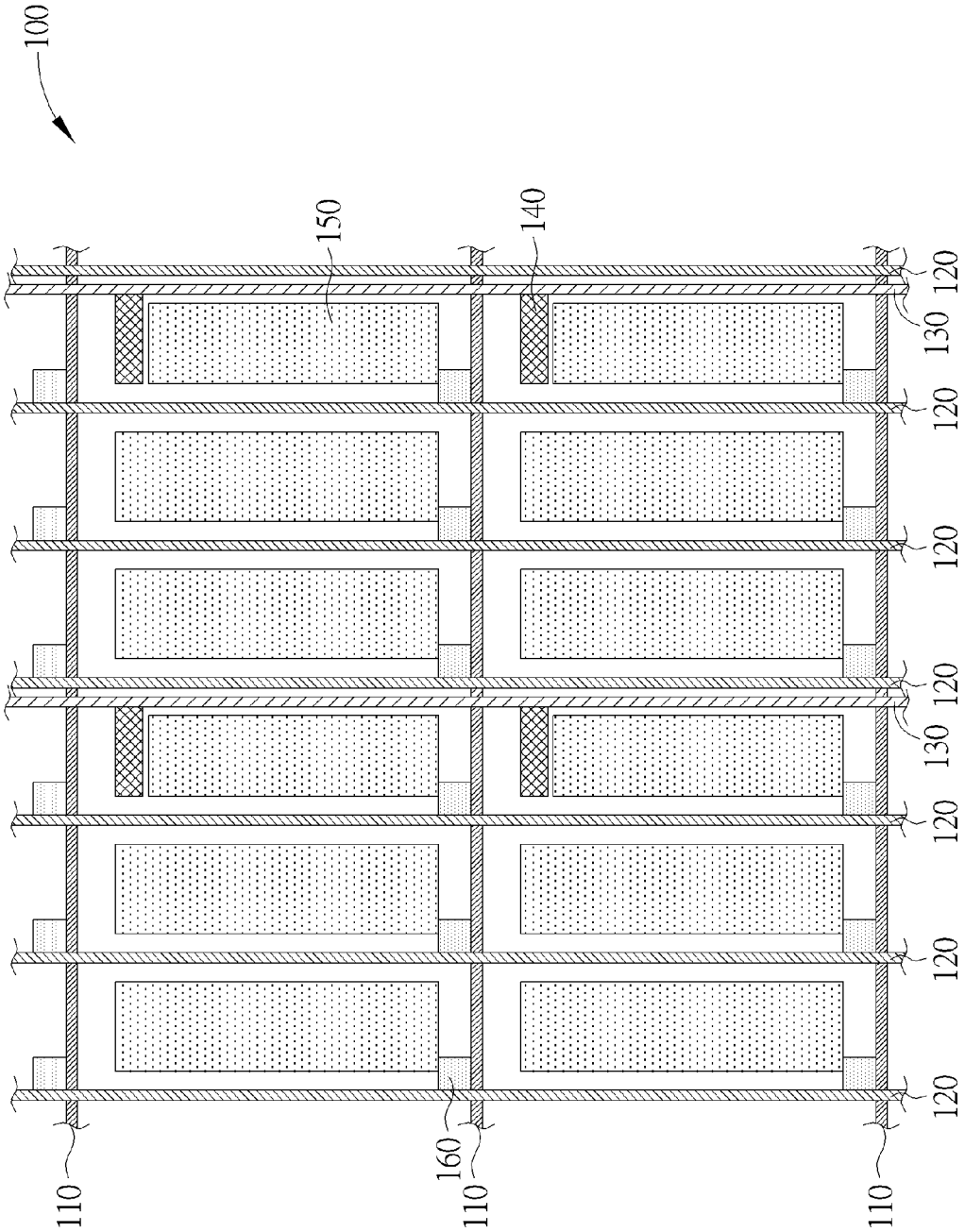


FIG. 1 PRIOR ART

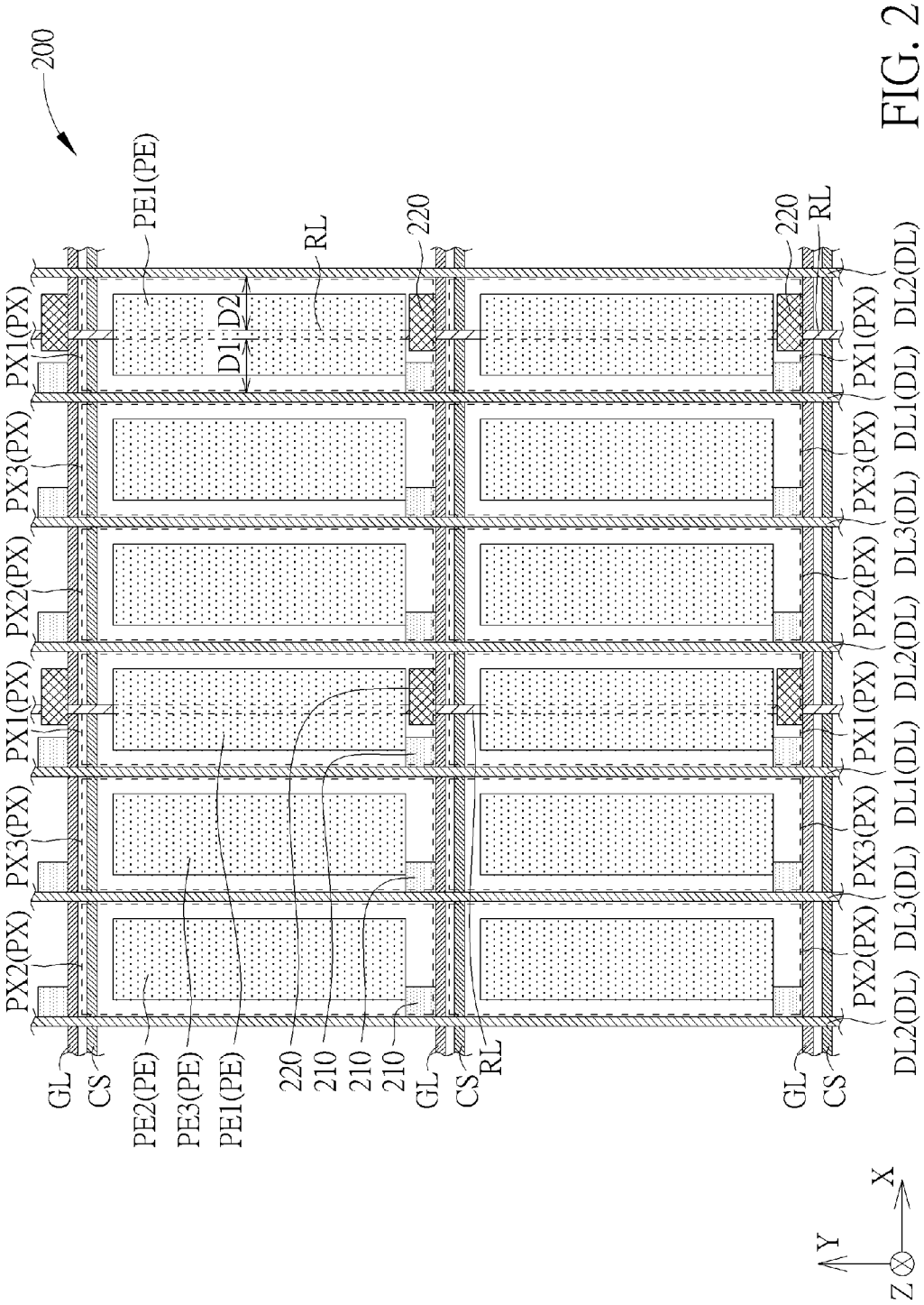

200
PE1(PE)
RL
220
220
RL
D1
D2
PX1(PX)
PX3(PX)
PX2(PX)
PX1(PX)
PX3(PX)
PX2(PX)
PX2(PX)
PX3(PX)
PX1(PX)
PX2(PX)
PX3(PX)
PX1(PX)
DL2(DL)
DL3(DL)
DL1(DL)
DL2(DL)
DL3(DL)
DL1(DL)
DL2(DL)
GL
CS
PE2(PE)
PE3(PE)
PE1(PE)
220
210
210
210
GL
CS
RL
GL
CS
X
Y
Z

FIG. 2

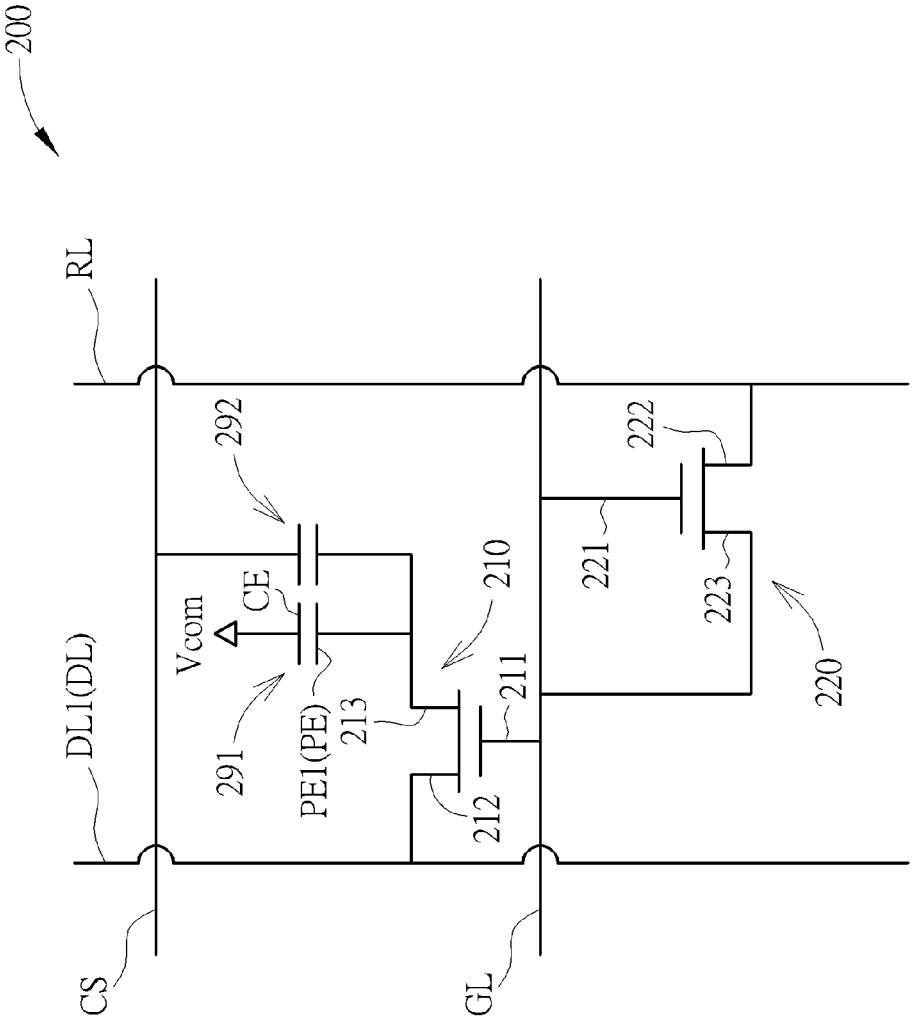

200
RL
292
222
221
210
Vcom
CE
223
DL1(DL)
291
PE1(PE)
213
211
220
212
CS
GL

FIG. 3

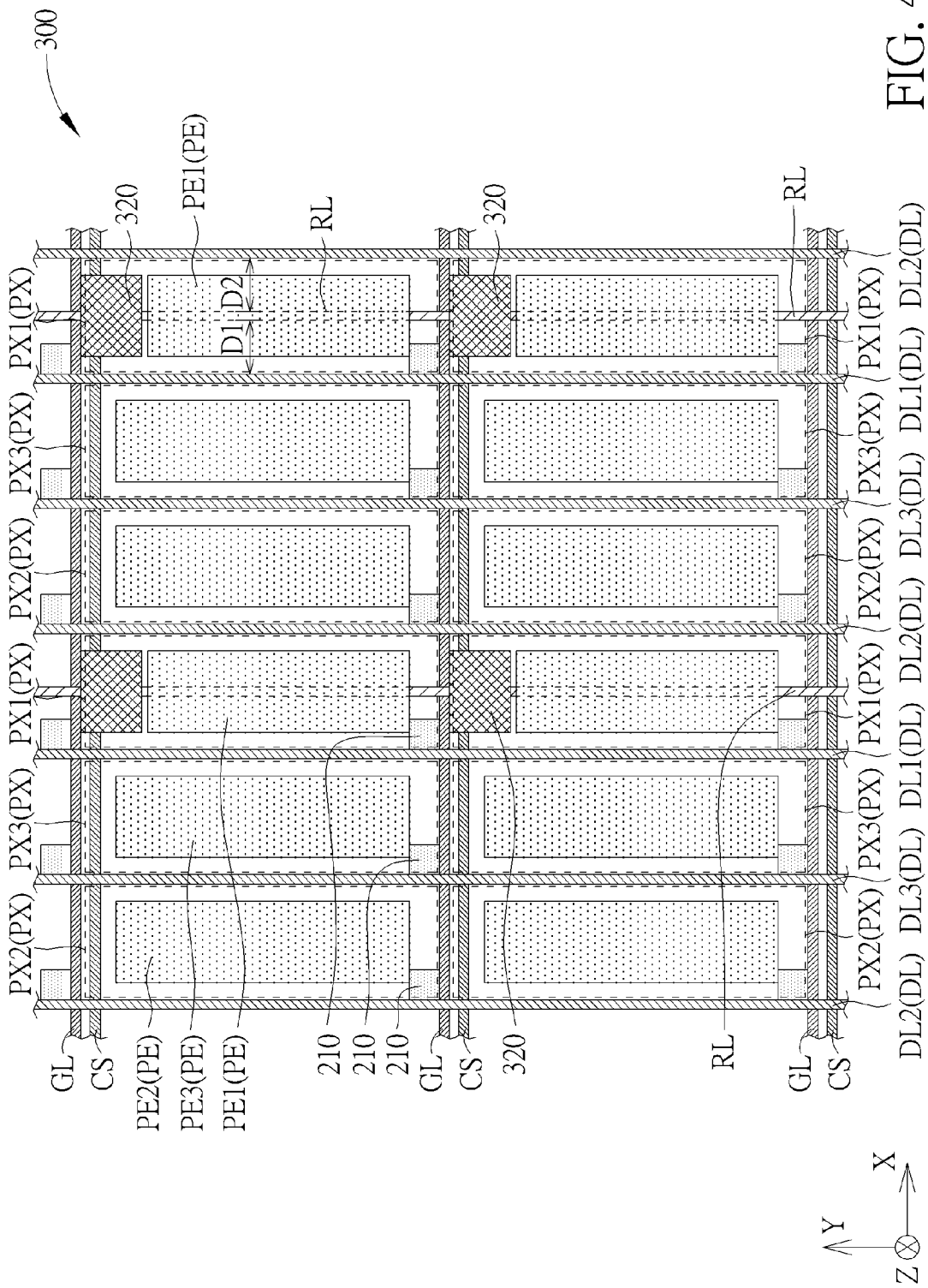

300
PE1(PE)
320
RL
D1
D2
PX1(PX)
PX3(PX)
PX2(PX)
DL1(DL)
DL2(DL)
DL3(DL)
GL
CS
PE2(PE)
PE3(PE)
210
X
Y
Z

FIG. 4

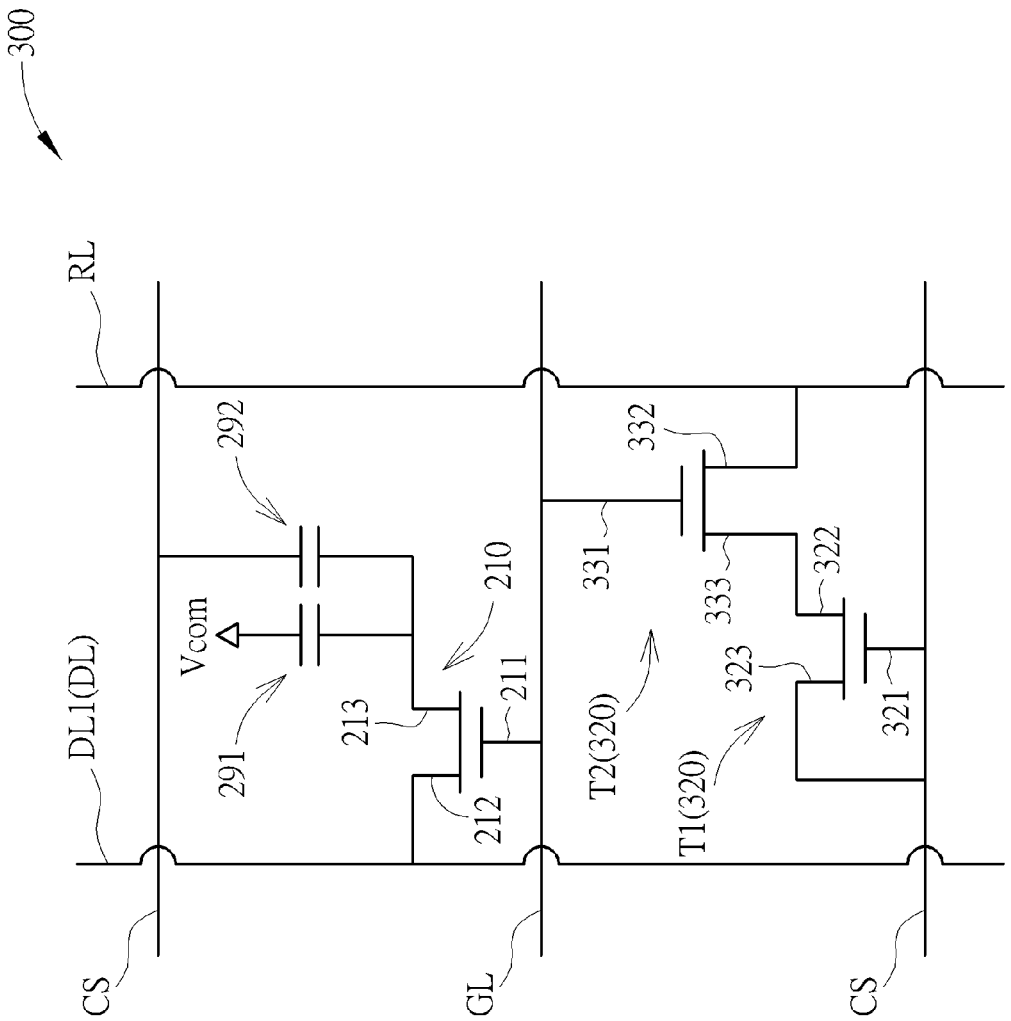

300
RL
DL1(DL)
CS
GL
CS
292
291
Vcom
213
212
210
211
331
332
333
322
323
321
T2(320)
T1(320)

FIG. 5

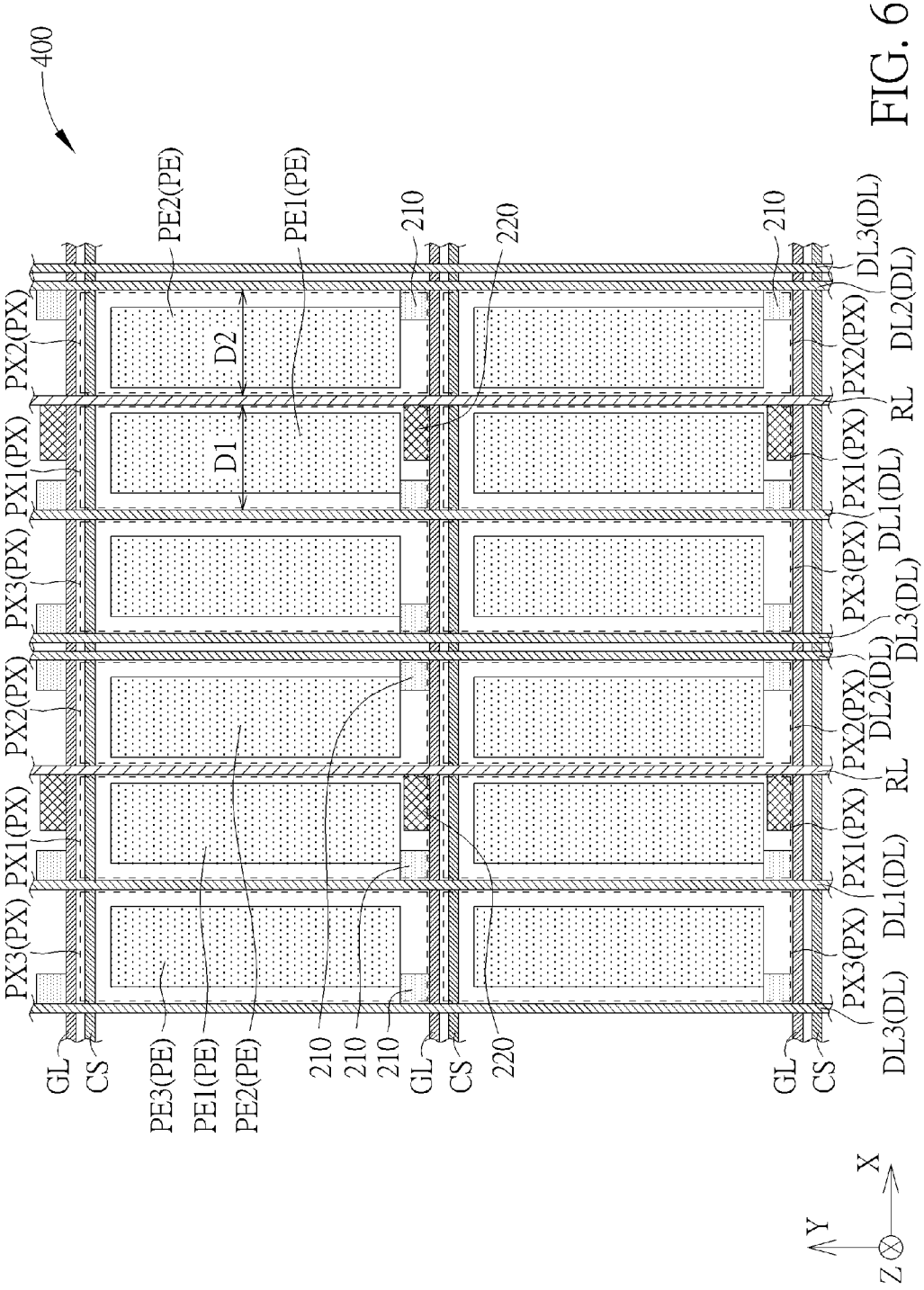

400
PE2(PE)
PE1(PE)
210
220
210
DL3(DL)
DL2(DL)
PX2(PX)
PX1(PX)
PX3(PX)
D2
D1
RL
DL1(DL)
GL
CS
PE3(PE)
PE1(PE)
PE2(PE)
210
210
210
GL
CS
220
GL
CS
DL3(DL)
DL1(DL)
RL
DL2(DL)
PX3(PX)
PX1(PX)
PX2(PX)
PX3(PX)
PX1(PX)
PX2(PX)
PX3(PX)
DL3(DL)
DL1(DL)
RL
DL2(DL)
PX2(PX)
PX1(PX)
PX3(PX)
X
Y
Z

FIG. 6

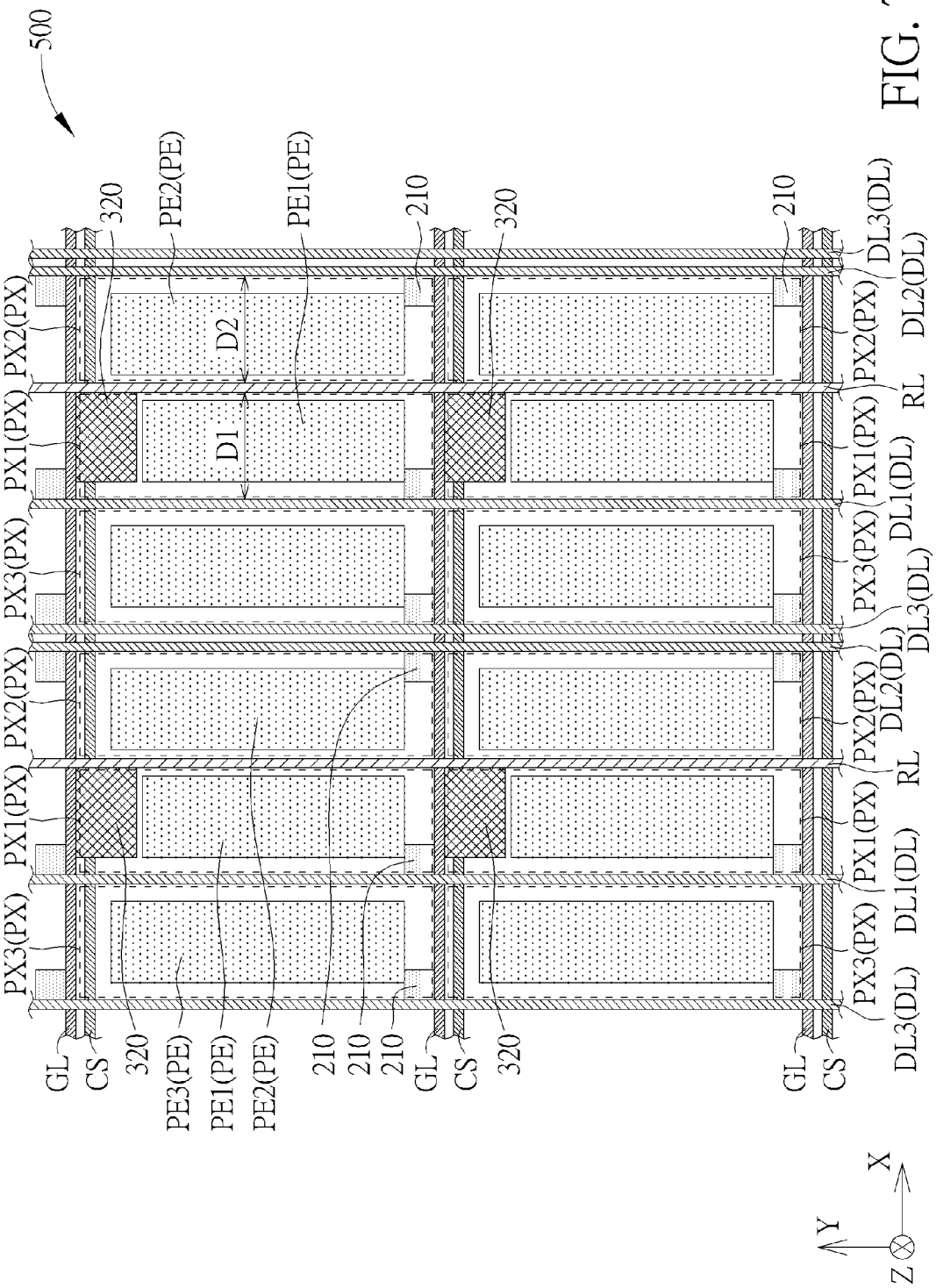

500
320
PE2(PE)
PE1(PE)
210
320
210
DL3(DL)
PX2(PX)
PX1(PX)
PX3(PX)
D2
D1
RL
DL2(DL)
DL1(DL)
GL
CS
PE3(PE)
X
Y
Z

FIG. 7

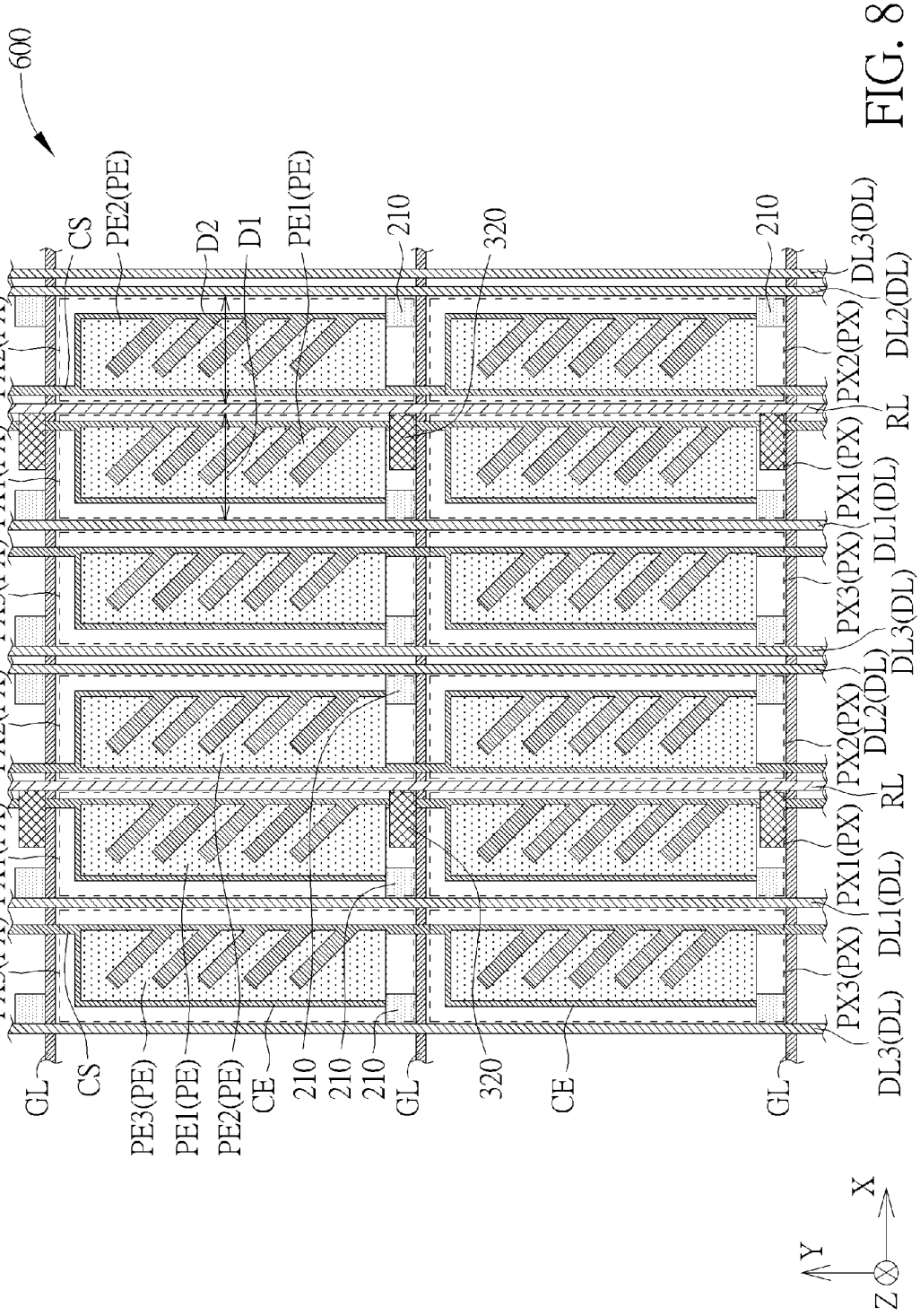

600
CS
PE2(PE)
D2
D1
PE1(PE)
210
320
210
PX2(PX)
PX1(PX)
PX3(PX)
PX2(PX)
PX1(PX)
PX3(PX)
DL3(DL)
DL2(DL)
RL
DL1(DL)
DL3(DL)
GL
CS
PE3(PE)
PE1(PE)
PE2(PE)
CE
210
210
210
GL
320
CE
GL
DL3(DL)
DL1(DL)
RL
DL2(DL)
DL3(DL)
X
Y
Z

FIG. 8

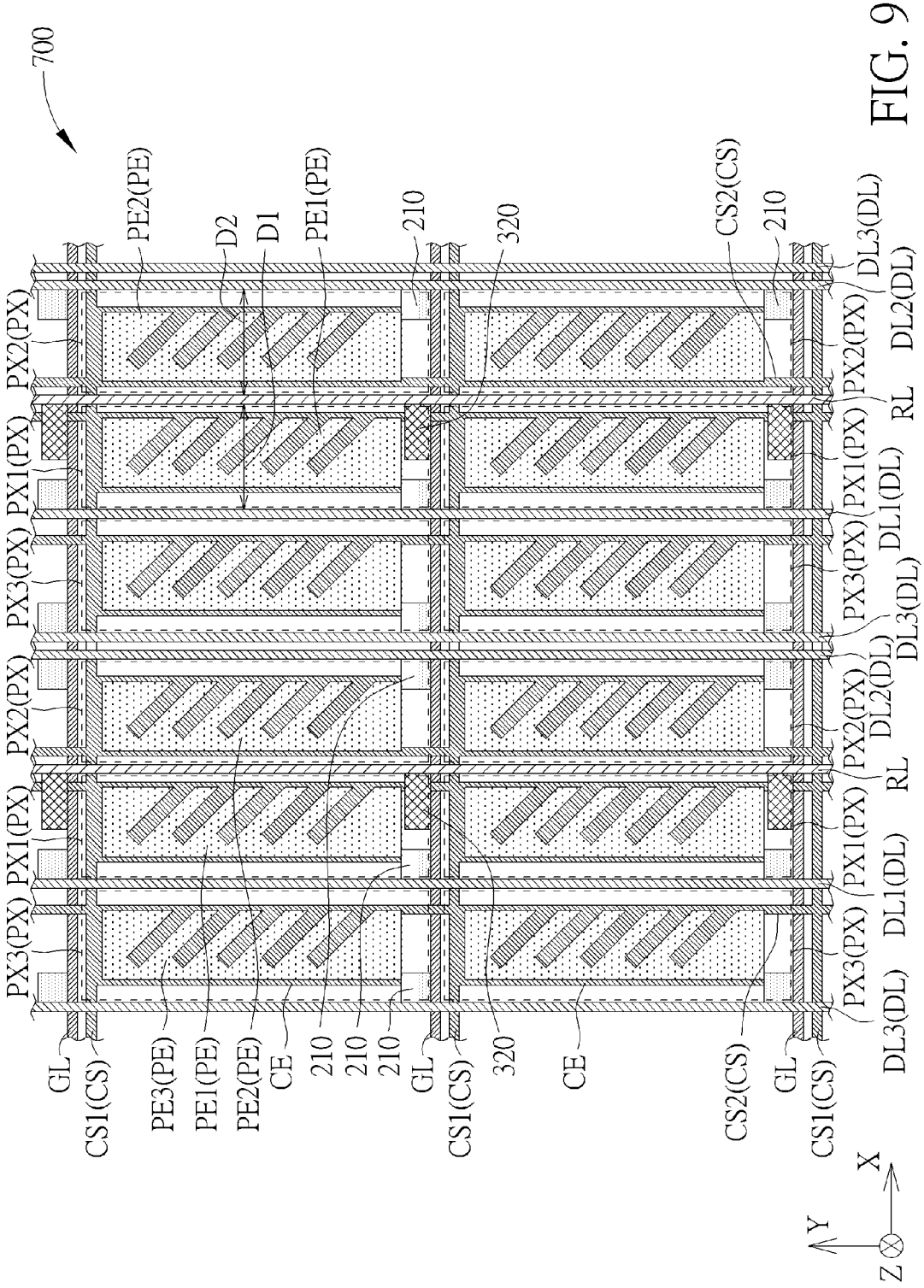

700
PE2(PE)
D2
D1
PE1(PE)
210
320
CS2(CS)
210
DL3(DL)
DL2(DL)
PX2(PX)
PX1(PX)
PX3(PX)
RL
DL1(DL)
GL
CS1(CS)
PE3(PE)
CE
X
Y
Z

FIG. 9

DISPLAY DRIVING CIRCUIT WITH PHOTO DETECTING INPUT

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. provisional application Ser. No. 61/728,242, filed Nov. 20, 2012.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a display driving circuit, and more particularly, to a display driving circuit with photo detecting input.

2. Description of the Prior Art

In recent years, touch sensing technologies have developed flourishingly, and electronic products, such as mobile phones, tablet PCs, GPS navigator systems, laptop PCs, and desktop PCs, which have both the touch sensing function and the display function, are commercialized accordingly. In the electronic products mentioned above, display regions of touch panels are mainly equipped with touch sensing functions. In other words, the display panels are replaced by the touch display panels. According to differences in structure designs, the touch display panels may include an out-cell type touch display panel, an in-cell type touch display panel, and an on-cell type touch display panel. In the out-cell type touch display panel, an independent touch panel is attached to a normal display panel. In the in-cell type touch display panel and the on-cell type touch display panel, touch sensing devices are disposed directly on an inner surface or an outer surface of a substrate in the display panel. For example, the touch sensing devices may be disposed on a color filter substrate or a thin film transistor array substrate of the traditional display panel so as to form the in-cell type touch display panel.

Please refer to FIG. **1**. FIG. **1** is a schematic diagram illustrating a conventional display driving circuit **100** with photo detecting input. The display driving circuit **100** is generally disposed on an array substrate. The display driving circuit **100** includes photo detecting units **140**, corresponding readout lines **130** and other general components of display driving circuits such as display switching devices **160**, gate lines **110** and data lines **120** crossing the gate lines **110**. The photo detecting units **140** are employed to perform touch sensing functions, and the readout lines **130** are used to transmit photo detecting signals. In the conventional design, the readout line **130** is disposed adjacently to one of the data lines **120** and substantially parallel to the data lines **120**. The photo detecting signals transmitted by the readout lines **130** tend to be interfered by display signals transmitted via the data lines **120**. Calculations and judgment about the photo detecting signals may be influenced accordingly, the signal processing may become more complicated, and the processing loading of the related integrated circuits may be increased.

SUMMARY OF THE INVENTION

It is one of the objectives of the present invention to provide a display driving circuit with photo detecting input. Positions of readout lines are modified to increase a distance between the readout line and a data line. The interference problem between the readout line and the data line may be improved, and purposes of enhancing accuracy of photo detecting signal judgment and lowering the processing loading of the related integrated circuits may be achieved accordingly.

To achieve the purposes described above, a preferred embodiment of the present invention provides a display driving circuit with photo detecting input. The display driving circuit includes a plurality of pixel regions, a plurality of pixel electrodes, a plurality of gate lines, a plurality of data lines, at least one photo detecting unit and at least one readout line. The pixel regions are arranged in a matrix configuration. The pixel electrodes are disposed in the pixel regions respectively. The gate lines extend along a first direction and are disposed parallel to one another. The data lines extend along a second direction and are disposed parallel to one another. The gate lines cross the data lines. The data lines include a first data line and a second data line disposed adjacently to each other, and none of the data lines is disposed between the first data line and the second data line. The photo detecting unit is disposed in at least one of the pixel regions, and the photo detecting unit is electrically connected to one of the gate lines. The readout line is electrically connected to the photo detecting unit. The readout line is disposed between the first data line and the second data line. A first spacing between the first data line and the readout line is wider than or equal to a second spacing between the second data line and the readout line, and the first spacing is smaller than or equal to triple the second spacing.

These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram illustrating a conventional display driving circuit with photo detecting input.

FIG. **2** is a schematic diagram illustrating a display driving circuit with photo detecting input according to a first preferred embodiment of the present invention.

FIG. **3** is a schematic diagram illustrating an equivalent circuit of the display driving circuit in the first preferred embodiment of the present invention.

FIG. **4** is a schematic diagram illustrating a display driving circuit with photo detecting input according to a second preferred embodiment of the present invention.

FIG. **5** is a schematic diagram illustrating an equivalent circuit of the display driving circuit in the second preferred embodiment of the present invention.

FIG. **6** is a schematic diagram illustrating a display driving circuit with photo detecting input according to a third preferred embodiment of the present invention.

FIG. **7** is a schematic diagram illustrating a display driving circuit with photo detecting input according to a fourth preferred embodiment of the present invention.

FIG. **8** is a schematic diagram illustrating a display driving circuit with photo detecting input according to a fifth preferred embodiment of the present invention.

FIG. **9** is a schematic diagram illustrating a display driving circuit with photo detecting input according to a sixth preferred embodiment of the present invention.

DETAILED DESCRIPTION

Certain terms are used throughout the description and following claims to refer to particular components. As one skilled in the art will understand, electronic equipment manufacturers may refer to a component by different names. This document does not intend to distinguish between components that differ in name but not function. In the following description and in the claims, the term "include" is used in an open-

ended fashion, and thus should be interpreted to mean "include, but not limited to . . . " In addition, the phrase "electrically connected to" or "structurally connected to" in this document includes direct or indirect connection approaches. Therefore, "a first device is connected to the second device" in this document means that "the first device is directly connected to the second device" or "the first device is connected to the second device via other devices or indirectly connected to the second device by other approaches".

Please refer to FIG. **2**. FIG. **2** is a schematic diagram illustrating a display driving circuit with photo detecting input according to a first preferred embodiment of the present invention. Please note that the figures are only for illustration and the figures may not be to scale. The scale may be further modified according to different design considerations. As shown in FIG. **2**, a display driving circuit **200** with photo detecting input is provided in this embodiment. The display driving circuit **200** includes a plurality of pixel regions PX, a plurality of pixel electrodes PE, a plurality of gate lines GL, a plurality of data lines DL, at least one photo detecting unit **220** and at least one readout line RL. The pixel regions PX are arranged in a matrix configuration. The pixel electrodes PE are disposed in the pixel regions PX respectively. The gate lines GL extend along a first direction X and are disposed parallel to one another. The data lines DL extend along a second direction Y and are disposed parallel to one another. The gate lines GL cross the data lines DL. In this embodiment, the first direction X is perpendicular to the second direction Y preferably, but not limited thereto. In addition, the pixel regions PX arranged in a matrix configuration are substantially defined by the crossed gate lines GL and data lines DL preferably, but not limited thereto. The data lines DL include a first data line DL**1** and a second data line DL**2** disposed adjacently to each other, and none of the data lines DL is disposed between the first data line DL**1** and the second data line DL**2**. The photo detecting unit **220** is disposed in at least one of the pixel regions PX, and the photo detecting unit **220** is electrically connected to one of the gate lines GL. The readout line RL is electrically connected to the photo detecting unit **220** so as to receive and transmit signals generated by the photo detecting unit **220** for calculating photo sensing results. The photo detecting unit **220** in the present invention may include at least one photo sensing device such as a photo sensing transistor preferably, but not limited thereto. It is worth noting that the photo detecting unit **220** in the present invention may simply be used as an ambient light sensor for detecting conditions and variations of ambient light, and the display driving circuit **200** may also include a plurality of photo detecting units **220** disposed and arranged in a specific manner for performing touch point positioning functions or image array functions.

In this embodiment, the readout line RL is disposed between the first data line DL**1** and the second data line DL**2**. The readout line RL is parallel to the data lines DL preferably. In other words, the readout line RL is substantially perpendicular to the gate lines GL preferably, but not limited thereto. A first spacing D**1** between the first data line DL**1** and the readout line RL is preferably wider than or equal to a second spacing D**2** between the second data line DL**2** and the readout line RL, and the first spacing D**1** is smaller than or equal to triple the second spacing D**2**. Preferably, the first spacing D**1** is smaller than or equal to double the second spacing D**2**, but not limited thereto. In other words, a distance between two adjacent data lines DL may be regarded as a width of each pixel region PX along the first direction X, a distance between the readout line RL and the adjacent data line DL is wider than or equal to a quarter of the width of each pixel region PX along the first direction X, and the distance between the readout line RL and the adjacent data line DL is smaller than or equal to three quarters of the width of each pixel region PX along the first direction X. Preferably, the distance between the readout line RL and the adjacent data line DL is wider than or equal to one third of the width of each pixel region PX along the first direction X, and the distance between the readout line RL and the adjacent data line DL is smaller than or equal to two thirds of the width of each pixel region PX along the first direction X, but not limited thereto. According to the above method of modifying the distance between the readout line RL and the adjacent data line DL, signal interference between the readout line RL and the data lines DL may be reduced, the accuracy of judging signals generated by the photo detecting unit **220** may be enhanced, and the processing loading of the related integrated circuits may be lowered. It is worth noting that, as shown in FIG. **2**, the first spacing D**1** may be equal to the second spacing D**2** preferably so as to equalize the influences between the readout line RL and the two adjacent data lines DL, but not limited thereto. Additionally, the readout line RL at least partially overlaps the pixel electrodes PE along a vertical projective direction Z. The vertical projective direction Z is substantially perpendicular to the first direction X and the second direction Y preferably, but not limited thereto.

More specifically, as shown in FIG. **2**, the display driving circuit **200** with the photo detecting input in this embodiment may further include a plurality of display switching devices **210** disposed in the pixel regions PX respectively. Each of the display switching devices **210** is electrically connected to one of the gate lines GL, one of the data lines DL and one of the pixel electrodes PE. In this embodiment, the pixel regions PX may include a first pixel region PX**1**, a second pixel region PX**2** and a third pixel region PX**3** aligned alternately along the first direction X. The pixel electrodes PE may include a first pixel electrode PE**1**, a second pixel electrode PE**2** and a third pixel electrode PE**3**. The first pixel electrode PE**1**, the second pixel electrode PE**2** and the third pixel electrode PE**3** are disposed in the first pixel region PX**1**, the second pixel region PX**2** and the third pixel region PX**3** respectively. In other words, the first pixel electrode PE**1** and the second pixel electrode PE**2** are disposed adjacently to each other along the first direction X. The first pixel electrode PE**1**, the second pixel electrode PE**2** and the third pixel electrode PE**3** are disposed and aligned alternately along the first direction X. In addition, the data lines DL may further include at least one third data line DL**3** disposed adjacently to the second data line DL**2** along the first direction X. The first data line DL**1**, the second data line DL**2** and the third data line DL**3** are electrically connected to the display switching devices **210** in the first pixel region PX**1**, the second pixel region PX**2** and the third pixel region PX**3** respectively, and data signals may then be transmitted to the display switching devices **210** in the pixel regions PX. It is worth noting that the first pixel region PX**1**, the second pixel region PX**2** and the third pixel region PX**3** may be used to present blue light, red light and green light respectively by employing corresponding color filters (not shown) or organic light emitting devices, and the different colors may be mixed to present a full color display effect. The photo detecting unit **220** in this embodiment is disposed in the first pixel region PX**1** presenting blue light, but the present invention is not limited thereto. In other preferred embodiments of the present invention, the photo detecting unit **220** may also be disposed in other pixel regions PX or even disposed in all pixel regions PX according to different design considerations.

Please refer to FIG. **2** and FIG. **3**. FIG. **3** is a schematic diagram illustrating an equivalent circuit of the display driving circuit in this embodiment. As shown in FIG. **2** and FIG. **3**, the display driving circuit **200** with the photo detecting input in this embodiment may further include a plurality of common lines CS extending along the first direction X and disposed parallel to one another. Each of the display switching devices **210** may include a transistor including a gate electrode **211**, a source electrode **212** and a drain electrode **213**. The gate electrode **211** of the display switching device **210** is connected to one of the gate lines GL, and the source electrode **212** is connected to one of the data lines DL. A coupling capacitor **291** is formed by a common electrode CE with common voltage Vcom, the pixel electrode PE and a material such as a liquid crystal material (not shown) disposed between the common electrode CE and the pixel electrode PE. A storage capacitor **292** is formed by the drain electrode **213**, the common line CS and a material such as a dielectric material (not shown) disposed between the drain electrode **213** and the common line CS. Additionally, the photo detecting unit **220** in this embodiment may include a photo sensing TFT including a gate electrode **221**, a source electrode **222** and a drain electrode **223**. A semiconductor layer such as an amorphous silicon layer, which may generate light beam induced current, in the photo sensing TFT maybe used to detect ambient light and measure intensity of the ambient light. It is worth noting that the gate electrode **221** of the photo detecting unit **220** is connected to one of the gate lines GL, and the drain electrode **223** of the photo detecting unit **220** is also connected to the gate line GL and thus is short-circuited to the gate electrode **221**. Additionally, the common lines CS are perpendicular to the readout line RL, and the source electrode **222** of the photo detecting unit **220** is connected to the readout line RL. When an optical signal is detected by the photo detecting unit **220**, the photo detecting unit **220** generates a current provided to a calculation integrated circuit (not shown) via the readout line RL. Therefore, the display switching device **210** of the display driving circuit **200** may be used to control the content to be display. In addition, the photo detecting unit **220** serves to detect an input optical signal provided from a light source such as a light pen or torch, or light variations caused by the shadow of an object such as a stylus or fingertip or intensity of reflection generated from the object, and take the input optical signal as an input control signal. Thus, the display driving circuit **200** displays and also allows input control via photo sensing.

The following description will detail the different embodiments of the present invention. To simplify the description, identical components in each of the following embodiments are marked with identical symbols. For making it easier to understand the differences between the embodiments, the following description will detail the dissimilarities among different embodiments and the identical features will not be redundantly described.

Please refer to FIG. **4** and FIG. **5**. FIG. **4** is a schematic diagram illustrating a display driving circuit with photo detecting input according to a second preferred embodiment of the present invention. FIG. **5** is a schematic diagram illustrating an equivalent circuit of the display driving circuit in this embodiment. As shown in FIG. **4** and FIG. **5**, a display driving circuit **300** with photo detecting input is provided in this embodiment. The display driving circuit **300** includes a plurality of pixel regions PX, a plurality of pixel electrodes PE, a plurality of gate lines GL, a plurality of data lines DL, a plurality of common lines CS, at least one photo detecting unit **320** and at least one readout line RL. The photo detecting unit **320** is disposed in at least one of the pixel regions PX, and the photo detecting unit **320** is electrically connected to one of the gate lines GL. The readout line RL is electrically connected to the photo detecting unit **320** so as to receive and transmit signals generated by the photo detecting unit **320** for calculating photo sensing results.

The difference between the display driving circuit **300** in this embodiment and the display driving circuit in the first preferred embodiment is that the photo detecting unit **320** is electrically connected to one of the common lines CS. More specifically, the photo detecting unit **320** may include a photo sensing transistor T**1** and a switch transistor T**2**. The switch transistor T**2** is connected to the photo sensing transistor T**1** so as to control the photo sensing transistor T**1** to be turned on or turned off. A gate electrode **321** of the photo sensing transistor T**1** is connected to one of the common lines CS, and a drain electrode **323** of the photo sensing transistor T**1** is also connected to the identical common line CS and thus is short-circuited to the gate electrode **321**. In addition, a gate electrode **331** of the switch transistor T**2** is connected to one of the gate lines GL, a source electrode **332** of the switch transistor T**2** is connected to readout line RL, and a drain electrode **333** of the switch transistor T**2** is connected to the source electrode **322** of the photo sensing transistor T**1**. When the photo sensing transistor T**1** detects an input optical signal provided from, for example, a light source such as a light pen or torch, or light variations caused by the shadow of an object such as a stylus or fingertip or intensity of reflection generated from the object, and the gate line GL is selected, which turns on the switch transistor T**2**, the current generated by the photo sensing transistor T**1** will be provided to the readout line RL. Additionally, in this embodiment, the display switching device **210** and the switch transistor T**2** may be connected to one identical gate line GL. The display switching device **210** and the switch transistor T**2** connected to the same gate line GL may be turned on or turned off together. The photo detecting units **320** connected to one identical readout line RL maybe turned on to detect optical signals at different time points, the position of the optical signal maybe calculated along the second direction Y, and the multiple touch points sensing function may be realized accordingly.

Please refer to FIG. **6**. FIG. **6** is a schematic diagram illustrating a display driving circuit **400** with photo detecting input according to a third preferred embodiment of the present invention. As shown in FIG. **6**, the difference between the display driving circuit **400** in this embodiment and the display driving circuit in the first preferred embodiment is that the first pixel electrode PE**1** and the second pixel electrode PE**2** are disposed between the first data line DL**1** and the second data line DL**2**. None of the pixel electrodes PE is disposed between the first pixel electrode PE**1** and the second pixel electrode PE**2**, and none of the data lines DL is disposed between the first pixel electrode PE**1** and the second pixel electrode PE**2**. None of the pixel electrodes PE is disposed between the second data line DL**2** and the third data line DL**3**, and none of the data lines DL is disposed between the second data line DL**2** and the third data line DL**3**. The readout line RL is disposed between the first data line DL**1** and the second data line DL**2**. The first spacing D**1** between the first data line DL**1** and the readout line RL is preferably wider than or equal to the second spacing D**2** between the second data line DL**2** and the readout line RL, and the first spacing D**1** is smaller than or equal to triple the second spacing D**2**. Preferably, the first spacing D**1** is smaller than or equal to double the second spacing D**2**, but not limited thereto. The distance between the readout line RL and the adjacent data line DL is wider than or equal to a quarter of a distance between the first data line DL**1** and the second data line DL**2** along the first direction X, and

the distance between the readout line RL and the adjacent data line DL is smaller than or equal to three quarters of the distance between the first data line DL**1** and the second data line DL**2** along the first direction X. Preferably, the distance between the readout line RL and the adjacent data line DL is wider than or equal to one third of the distance between the first data line DL**1** and the second data line DL**2** along the first direction X, and the distance between the readout line RL and the adjacent data line DL is smaller than or equal to two thirds of the distance between the first data line DL**1** and the second data line DL**2** along the first direction X, but not limited thereto. It is worth noting that, as shown in FIG. **6**, the first spacing D**1** may be equal to the second spacing D**2** preferably, and the readout line RL is disposed between the first pixel electrode PE**1** and the second pixel electrode PE**2** preferably so as to equalize the influences between the readout line RL and the two adjacent data lines DL, but not limited thereto. According to the above method of modifying the distance between the readout line RL and the adjacent data line DL, the distance between the readout line RL and the adjacent data line DL may be increased without lowering the aperture ratio of the pixel region PX because of the position of the readout line RL. The photo detecting performance and the display effect may be enhanced concurrently.

Please refer to FIG. **7**. FIG. **7** is a schematic diagram illustrating a display driving circuit **500** with photo detecting input according to a fourth preferred embodiment of the present invention. As shown in FIG. **7**, the difference between the display driving circuit **500** in this embodiment and the display driving circuit in the third preferred embodiment is that the photo detecting unit **320** is electrically connected to one of the common lines CS. The detail characteristics of the photo detecting unit **320** have been described in the second preferred embodiment and will not be redundantly described.

Please refer to FIG. **8**. FIG. **8** is a schematic diagram illustrating a display driving circuit **600** with photo detecting input according to a fifth preferred embodiment of the present invention. As shown in FIG. **8**, the difference between the display driving circuit **600** in this embodiment and the display driving circuit in the fourth preferred embodiment is that the common lines CS in this embodiment extend along the second direction Y and are disposed parallel to one another. The photo detecting unit **320** is electrically connected to one of the common lines CS. Additionally, the display driving circuit **600** may further include a plurality of common electrodes CE disposed in the pixel regions PX respectively. Each of the common lines CS is connected to corresponding common electrodes CE so as to provide common signals, and the photo detecting unit **320** is electrically connected to at least one of the common electrodes CE. An in-pane switching (IPS) liquid crystal driving mode may be executed by modifying the shapes of the pixel electrodes PE and the electrical field formed between the common electrode CE and the pixel electrode PE in each pixel region PX, but not limited thereto.

Please refer to FIG. **9**. FIG. **9** is a schematic diagram illustrating a display driving circuit **700** with photo detecting input according to a sixth preferred embodiment of the present invention. As shown in FIG. **9**, the difference between the display driving circuit **700** in this embodiment and the display driving circuit in the fifth preferred embodiment is that the common lines CS in this embodiment may include a plurality of first common lines CS**1** extending along the first direction X and a plurality of second common lines CS**2** extending along the second direction Y. Each of the common electrodes CE is connected to the first common lines CS**1** and the second common lines CS**2** so as to transmit common signals. The photo detecting unit **320** is electrically connected to at least one of the common electrode CE.

To summarize the above descriptions, in the display driving circuit with the photo detecting input of the present invention, the distance between the readout line and the adjacent data line is increased, and the signal interference between the readout line and the data lines may be reduced. The accuracy of judging the signals generated by the photo detecting unit may be enhanced, and the processing loading of the related integrated circuits maybe lowered. Additionally, the allocation of the data lines may be further modified to increase the distance between the readout line and the adjacent data line without lowering the aperture ratio of the pixel region. The photo detecting performance and the display effect maybe enhanced concurrently.

Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

What is claimed is:

1. A display driving circuit with photo detecting input, comprising:

a plurality of pixel regions, arranged in a matrix configuration;

a plurality of pixel electrodes, disposed in the pixel regions respectively;

a plurality of gate lines, extending along a first direction and disposed parallel to one another;

a plurality of data lines, extending along a second direction and disposed parallel to one another, wherein the gate lines cross the data lines, the data lines comprise a first data line and a second data line disposed adjacently to each other, and none of the data lines is disposed between the first data line and the second data line;

at least one photo detecting unit, disposed in at least one of the pixel regions, wherein the photo detecting unit is electrically connected to one of the gate lines; and

at least one readout line, electrically connected to the photo detecting unit, wherein the readout line is disposed between the first data line and the second data line, a first spacing between the first data line and the readout line is wider than a second spacing between the second data line and the readout line, and the first spacing is smaller than or equal to triple the second spacing.

2. The display driving circuit of claim **1**, wherein the first spacing is smaller than or equal to double the second spacing.

3. The display driving circuit of claim **1**, wherein the pixel regions are defined by the crossed gate lines and data lines, and the readout line at least partially overlaps the pixel electrodes along a vertical projective direction.

4. The display driving circuit of claim **1**, further comprising a plurality of common lines extending along the first direction and disposed parallel to one another, wherein the photo detecting unit is electrically connected to one of the common lines.

5. The display driving circuit of claim **1**, further comprising a plurality of common lines extending along the second direction and disposed parallel to one another, wherein the photo detecting unit is electrically connected to one of the common lines.

6. The display driving circuit of claim **1**, further comprising a plurality of common electrodes disposed in the pixel regions respectively, wherein the photo detecting unit is electrically connected to at least one of the common electrodes.

7. The display driving circuit of claim **1**, further comprising a plurality of display switching devices disposed in the pixel

regions respectively, wherein each of the display switching devices is electrically connected to one of the gate lines, one of the data lines and one of the pixel electrodes.

8. The display driving circuit of claim **1**, wherein the pixel electrodes comprising a first pixel electrode and a second pixel electrode disposed adjacently to each other along the first direction, and none of the pixel electrodes is disposed between the first pixel electrode and the second pixel electrode.

9. The display driving circuit of claim **8**, wherein the first pixel electrode and the second pixel electrode are disposed between the first data line and the second data line.

10. The display driving circuit of claim **9**, wherein the readout line is disposed between the first pixel electrode and the second pixel electrode.

11. The display driving circuit of claim **1**, wherein the data lines further comprises at least one third data line disposed adjacently to the second data line along the first direction, wherein none of the data lines and none of the pixel electrodes are disposed between the second data line and the third data line.

12. The display driving circuit of claim **1**, wherein the readout line is perpendicular to the gate lines.

13. The display driving circuit of claim **1**, wherein the photo detecting unit comprises a photo sensing device.

* * * * *